

**UNITED AIRCRAFT CORPORATION**  
**RESEARCH LABORATORIES**  
**EAST HARTFORD, CONN.**


A-920057-4

Research on the Collision Probabilities  
of Electrons and Cesium Ions in Cesium  
Vapors

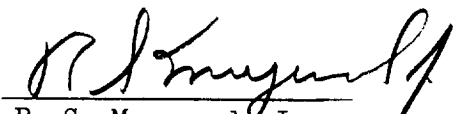
Quarterly Status Report No. 4  
February 1, 1963 through April 30, 1963  
Contract NASr-112

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SUMMARY

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This report describes work conducted by the United Aircraft Corporation Research Laboratories during the period February 1, 1963, through April 30, 1963, on a research program to determine the collision cross sections of ions and electrons in cesium vapor. These basic data are necessary to formulate a quantitative, theoretical description of any device using ionized cesium gas.

During the preceeding report periods, preliminary measurements have been made of electron-atom and ion-atom collision cross sections to demonstrate the validity of the experimental techniques. A report on the results obtained from the preliminary electron collision cross-section measurements was presented at the Department of Defense Symposium on Thermionic Energy Conversion held at Colorado Springs in May 1962. Progress during the previous report periods was also made in refinements to the instrumentation to increase the signal to noise ratio of the measurements and thereby provide for increased accuracy.

Also, the vacuum system and other components were completely fabricated for the ion cross-section experiment. With a dummy collision chamber, ion beams with energies of 0.19 to 9.1 eV have been focused through the collision chamber and measured with an ion multiplier system. Operation of the multiplier was satisfactory and currents as low as  $10^{-18}$  amps have been detected with this system. The final system with an electroformed copper collision chamber has been assembled, and experiments are presently underway to determine the cross section of cesium ions interacting with cesium vapor.

Progress in the electron collision experiment has been in the formulation of a two-term expansion for the collision frequency to represent the velocity dependence and the acquisition of experimental data. Measurements are under way to determine

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the collision cross-section at higher energies using a resistive heating technique to increase the cesium vapor temperature in the waveguide. At the conclusion of this contract May 31, 1963, a final report will be prepared presenting the cross sections for collisions of ions and electrons with cesium atoms.

## ION COLLISION CROSS SECTION MEASUREMENTS

### Introduction

A modified Ramsauer apparatus which uses an electroform copper collision chamber is being employed to measure the total collision cross section of cesium ions with cesium atoms in an energy range of 0.1 to 10 eV. The preceeding quarters have been engaged in the design and fabrication of the experimental apparatus with which the collision cross-section measurements will be conducted.

### Experimental Apparatus

In this period fabrication of the apparatus for the ion collision cross-section experiments has been completed, and final cross-section measurements are presently underway. The electroformed collision chamber shown in Fig. 1 has been successfully fabricated with a minimum of 0.020-inch plate in all areas of the chamber. Sharp well-defined slits as shown in Fig. 1 have been achieved in both re-entrant areas of this chamber with a minimum plating thickness in these areas of 0.030 inch. With a dummy collision chamber in the final vacuum system shown in Fig. 2, ion beams of 0.1 to 9.1 eV have been successfully detected. In the course of these measurements the presence of sodium, potassium, and rubidium ions was also detected. These other alkali metals amounted to 0.1% impurity content in the cesium which was used in the ionizer gun.

It was also found that two sets of deflection plates were required to accurately focus the ion beam through the collision chamber. In the course of these measurements an ion multiplier was used to measure the current which exited the last slit of the collision chamber. The multiplier acted normally throughout the tests, and currents as low as  $10^{-18}$  amps were detected with this system. The ion multiplier is positioned in one of the pumping ports of the vacuum system so that a liquid nitrogen cold trap separates the diffusion pump from the multiplier and so that both a conventional Faraday cup-type collector and the ion multiplier system can be employed in the measure-

ments without any system changes. When the multiplier is in operation, an acceleration plate is employed to deflect the ions from their trajectory determined by the restraints of the collision chamber and magnetic field intensity into the first dynode of the multiplier. As would be expected, there is a strong correlation between ion beam energy and required potential applied to the acceleration plate for the best ion beam focus. Due to the fact that the alkali metal impurities in the cesium employed in the ionizer gun were also producing detectable ion currents, the complete energy spectrum was swept to accurately determine the cesium ion current peak in the spectrum with the system generating a relatively high energy ion beam. This beam was then gradually reduced in energy by changing accelerating and focusing potentials in the ionizer gun and the magnitude of the applied magnetic field. After these initial measurements were made to determine the capabilities of the ionizer gun, focusing system, and ion multiplier, the dummy collision chamber was removed from the system and replaced by the electroformed collision chamber with appropriate heating blocks to control the neutral cesium pressure in the chamber. Presently, cross-section information is being obtained with this system.

## ELECTRON COLLISION CROSS-SECTION MEASUREMENT

### Introduction

The electron-caesium atom collision cross section is being determined by measuring the width of the electron cyclotron resonance absorption spectra of a caesium plasma in a magnetic field using a microwave spectrometer. The width of the cyclotron resonance line is related to the electron collision frequency in the caesium gas, resulting in an absolute determination of the collision frequency.

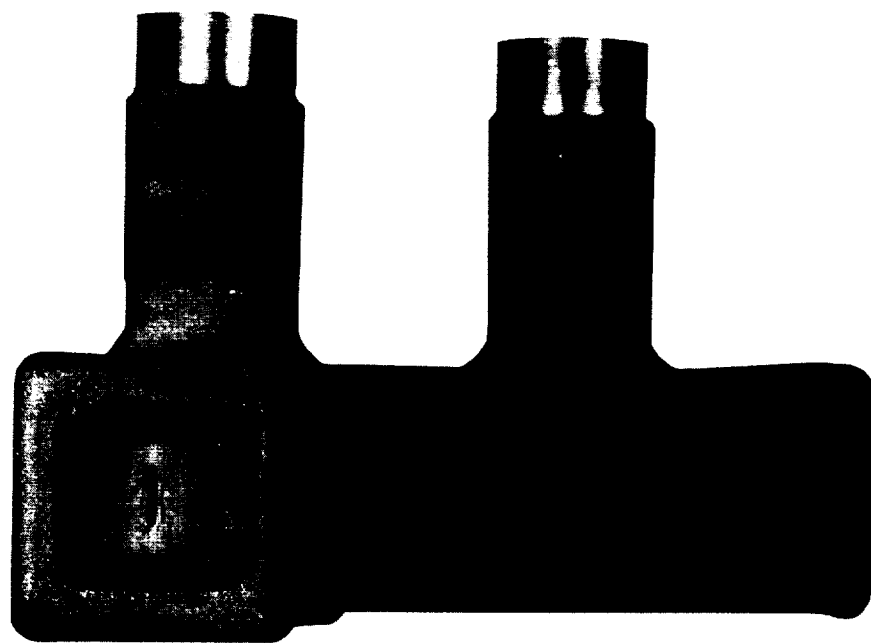
### Collision Frequency Representation

To more accurately determine the collision frequency of electrons in caesium vapor, a two-term representation of the electron collision frequency was made. This takes the form  $\nu_c$  and is equal to  $A + BV^h$ . During this period computer solutions for the line shape have been made using numerical techniques. The ratios of a number of the widths of the absorption spectra are being used to determine the values of A, B, and h in the collision frequency representation. The data shows a consistent trend with the measured temperature dependence obtained by varying the ambient temperature of the caesium vapor when the constants A, B, and h are varied in a systematic manner between spectra taken at different temperatures.

### Instrumentation

The test apparatus was operated at the highest oven temperature possible with the existing apparatus and collision cross-section data were obtained. The experiment is being conducted in caesium vapor heated to higher temperatures through techniques reported in progress report A-920057-3. The final cross-section values are being obtained and will be reported in the final report for the contract.

ELECTRO-FORMED COPPER COLLISION CHAMBER



FINAL ION COLLISION CROSS-SECTION APPARATUS

